HOTLINE
PRINCETON PLASMA PHYSICS LABORATORY
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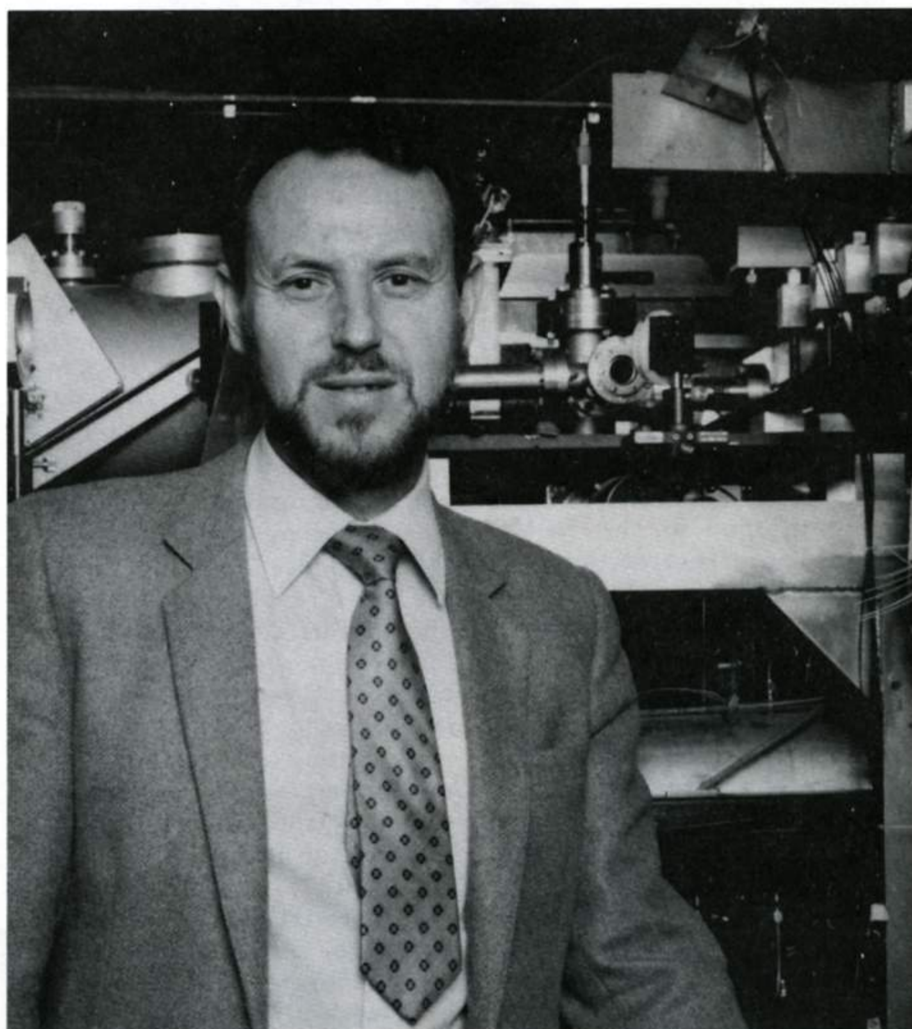
Progress Toward Soft X-ray Laser Reported

At last week's annual meeting of the Division of Plasma Physics of the American Physical Society (APS), Dr. Szymon Suckewer announced that his group has made significant strides toward a demonstration of the X-ray lasing process. Their current goal is the development of a soft X-ray laser which can be used as a diagnostic tool in PPL's magnetic fusion energy research.

Suckewer and his team of researchers have been using a CO_2 laser to produce a dense carbon plasma column of 2-5 cm length, which is held to a 1-2 mm diameter by confinement in a strong magnetic field. They have observed a 100-fold increase of the 182-Angstrom X-ray line in the direction along the plasma column, which is due to the desired stimulated-emission process. This result corresponds to an amplifier 'gain' of about 6.5. A gain of 10 is considered characteristic of entry into the full laser regime.

At the heart of the Princeton method is the utilization of a fast recombining plasma. Temperature is increased to a point at which the carbon atoms become completely ionized, or totally stripped of electrons. The plasma then cools rapidly by intensive radiation losses, causing ions to recombine with free electrons. Because recombination occurs primarily on the higher energy levels (outer orbits) while lower levels (inner orbits) do not capture electrons, an unstable condition known as population inversion occurs. Electrons in the higher energy levels then avalanche to the lower levels to bring about a more stable electron configuration. In the process, each electron loses energy in the form of a photon of X-ray light. The lasing process oc-



Dr. Szymon Suckewer

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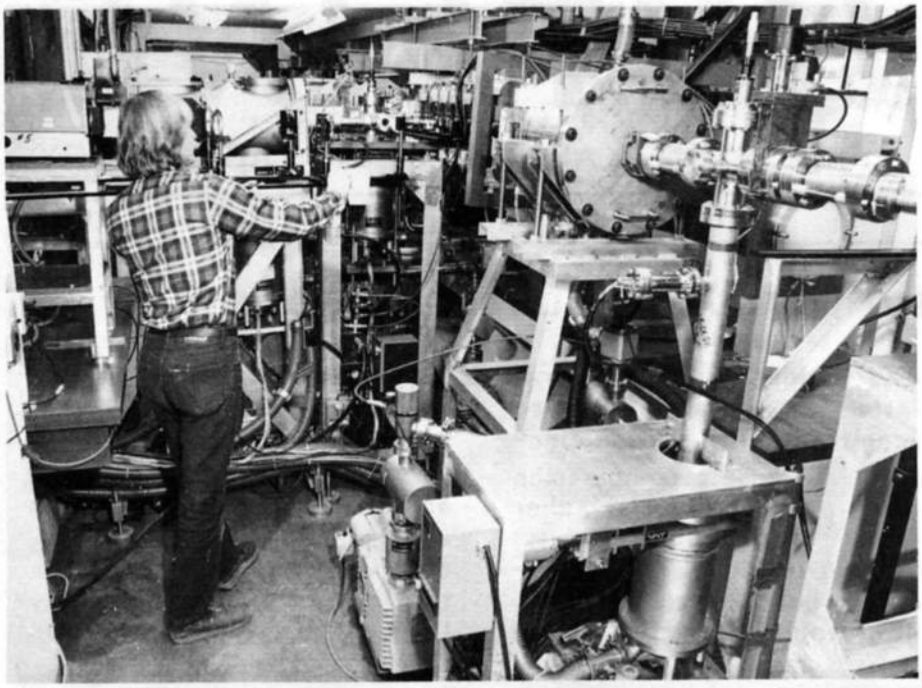

David Voorhees adjusts a mirror on the x-ray laser. The experimental device is close to achieving lasing action.

curs when the photons produced in this fashion stimulate the emission of additional photons from other ions, initiating a chain of such events. The result is an intense, coherent X-ray pulse of a single wavelength.

The search for possible ways of building X-ray lasers began soon after visible light lasers were developed in the early 1960's. The effect of the development of X-ray lasers on physics, medicine, biology, and on technology in general may surpass that of existing lasers with wavelengths in the ultraviolet, visible, and infrared range of the spectrum.

Plasma physicists would make extensive use of X-ray lasers in measurements of temperature, impurity densities, and ion transport in fusion plasmas. In the area of solid state physics, the availability of lasers in the X-ray region would allow a substantial improvement in the ability to analyze the structure of crystalline solids grown for a multitude of uses in electronics, especially in the computer industry.

Two new physics applications, X-ray holography and microscopy, might emerge allowing the availability of three-dimensional pictures in all present-day and future X-ray imaging applications, including medical diagnostics. X-ray microscopes would allow greater resolution than achieved by present-day electron beam systems. In medicine the finely focused X-ray laser would allow a substantially improved degree of localization in the use of CAT scanners and similar devices. Only tissue under study would be expose to radiation, greatly minimizing the patient's exposure. The short wavelength nature of X rays, coupled with a high degree of laser focus, would yield medical X-rays with greatly enhanced detail over those currently available.

Dr. Suckewer's interest in X-ray lasers dates back to the early 70's. The idea of using the fast radiation cooling of a magnetically confined plasma column for X-ray laser development grew from observations made on PPL's Floating Multipole Experiment (FM-1) in which Dr. Suckewer participated. Strong population inversions were observed for the first time in a magnetic fusion device during the final weeks of FM-1 operation in late 1975. This led to extensive theoretical investigations, during which Dr. Harold Furth provided the support and encouragement that allowed the experiment to commence in September 1979. Funding was obtained from the US DOE Office of Basic Energy Sciences.

In looking to the future, the group's near term goal is to increase gain by increasing the effective length of the plasma column and installing a state-of-the-art multilayered mirror, recently developed and supplied to Princeton by Dr. T. Barbee of Stanford University. For the long-term, the PPL team is planning the development of a system which will permit high gain and lasing action in a shorter wavelength region.

Members of Dr. Suckewer's experimental team include physicist Charles Skinner and assistant engineer David Voorhees, who have been with the project since its early days, and two graduate students, Howard Milchberg and Christopher Keane. Recently, engineer Lewis Meixler and theoretical physicist Ernest Valeo also joined the group.

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The word Laser

The word Laser is an acronym for Light Amplification by Stimulated Emission of Radiation. Scientists begin the lasing process with a group of atoms, each of which has electrons circling its nucleus at various levels, or orbits. By exposing these atoms to an energy source (such as an electrical charge or a flashlamp, for example), the atoms are "excited." That is, an electron from a lower energy orbit in the atom is boosted into a higher energy orbit. The atom is unstable in this state, and the displaced electron soon drops back into its former orbit to regain stability. When that transition occurs, energy is released in the form of a photon, or particle of light.

The photons initially released by the electron transition travel towards the ends of the laser cavity, where they may strike a full or partial mirror and be bounced back into the laser cavity. As the photons traverse the cavity (oscillation), they stimulate many other high energy electrons to return to their low energy orbits simultaneously. The large quantity of photons thus released drops into phase and frequency with the initial photons, rather like a marching band following a drum major. When conditions are right, the effect multiplies to produce the high-intensity, coherent light beam that emerges from the laser cavity through the partial mirror.

Computer Assisted Design

The laboratory has enhanced its drafting and design capability by acquiring a Computer Vision Corporation Computer Aided Design and Computer Aided Manufacturing (CAD/CAM) system. The new system is housed in a converted high-bay area of the New Guggenheim Building on B-Site.

CAD/CAM systems have been available in industry for approximately 15 years, according to CAD/CAM Project Head Nick Krisa. Fusion community interest in CAD/CAM grew approximately five years ago, resulting in a recommendation by the Magnetic Fusion Computer Users' Advisory Committee for further investigation. The Office of Fusion Energy authorized $315,000 in FY83 as CAD/CAM system seed money for each of the five major national fusion laboratories, which include Lawrence Livermore, GA Technologies, Los Alamos, Oak Ridge, and Princeton. Additional monies were contributed by each laboratory to enhance the basic CAD/CAM configuration.

The Office of Fusion Energy appointed Krisa chairman of the CAD/CAM Committee, which was chartered to provide compatible systems to these major laboratories. A key requirement for the systems was the capability to interchange design data from one facility to another. This requirement stems from the recognition that future fusion devices may include design features which are incorporated into fusion experiments at several different fusion laboratories. Also, future fusion design efforts promise to be so large as to require extensive cooperation between laboratories. It is intended that designers will do work on the CAD/CAM system, communicate information between laboratories through the National Magnetic Fusion Energy (NMFE) satellite network, and perform large scale analyses at the NMFE Computer Center at Livermore, CA.

It took almost a year to finalize the specification, evaluation criteria, and performance

Designers working on the CAD/CAM system can rotate, enlarge, reduce or add color to the three-dimensional images on their workstation monitor screen by entering a simple set of commands.

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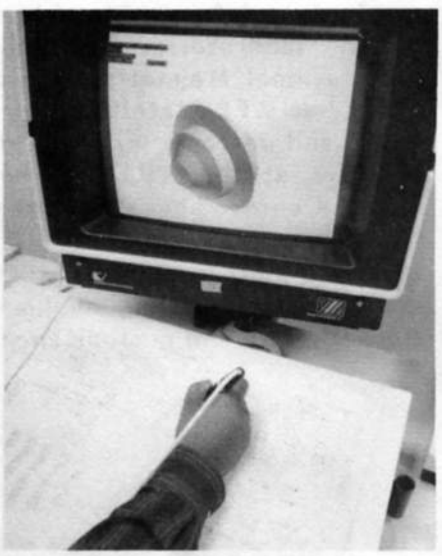
tests. It was a monumental task to get all five labs to agree; however, a consensus was necessary on each detail, so there would be no misunderstanding during the evaluation phase. Of the twenty-two vendors who requested a copy of the solicitation, seven vendors actually submitted bids. A Performance Team traveled to each of the selected vendors, testing the functionality of the bid hardware and software. These results, coupled with the results of the technical evaluation of the original bid, determined the vendor's score. The CAD/CAM Committee ultimately selected Computer Vision Corporation of Bedford, MA as the successful bidder.



Operators use a stylus on a digitizer board as one way of entering information into the CAD/CAM system.

The CAD/CAM system is expected to standardize and automate electrical and mechanical engineering design and drafting work. Currently, design work on printed circuit boards (PCB) can take months to complete. With the CAD/CAM system, the schematic diagram is developed on the computer. The software will perform auto-placement of components on the PCB and optimize electrical routes. The completed board design will then be sent to an outside vendor for fabrication.

The system also provides the ability to edit each design manually, and can isolate sections of the circuit board for closer inspection.

The CAD/CAM system contains mechanical, electrical, and plant design applications software. The hardware consists of multiple processors performing specific functions: one main processor responds to interactive commands typed by the workstation operator, while another high speed processor provides the modeling and analysis. Other processors generate graphics and allow images created at the workstations to be rotated, color shaded, enlarged or reduced, and repositioned on the monitor screen.

Each workstation includes a high resolution color monitor screen (1024x1280 pixels), digitizer local plotter. A Versatec 36" plotter is also available to produce large drawings and plots.

Two-dimensional CAD/CAM mechanical drawings usually begin as a three-dimensional model. The basic structure of a component can have as many as 256 layers entered into the system. The process is similar to examining view-graphs piled atop one another; views can be "peeled" back to expose the structure beneath. Designers can also add color to their diagrams, or simply apply color to various sections of the design.

At present, Krisa is establishing a group of eight trained operators to run the CAD/CAM system. Staff members from the Mechanical Engineering, Electronics and Electrical Engineering, and Engineering Design and Analysis Divisions are being sent to two-week Computer Vision training courses. The group will then return to PPL and practice applying what they have learned. Krisa estimated that it will take three to four months for the CAD/CAM operators to become capable in using the system.

The eight trainees will work five and a half hour shifts on the work stations, spending the remainder of their time coordinating system input and output with design engineers.

Princeton is the first of the laboratories to receive the system; other deliveries are contingent upon its successful operation here. It is anticipated that the remainder of the systems will be delivered this month.

Anyone interested in a demonstration of the CAD/CAM system should contact Krisa at ext. 3402 to arrange an appointment.

The PPL HOTLINE is issued by the Princeton University Plasma Physics Laboratory, a research facility supported by the United States Department of Energy. Correspondence should be directed to PPL Information Services, Module 2, C-Site, James Forrestal Campus, ext. 2754.

Carpooling

In an attempt to stimulate ridesharing, the HOTLINE is publishing the names of the following employees who are interested in carpooling:

Michael Koenig	70 Martin Road Livingston, NJ	x3232	8:30 a.m.-5:30 p.m.	LOB
Lee Ratzan	4 Arbit Road E. Brunswick, NJ	x3228	9 a.m.-5 p.m.	LOB
Don Greene	Newark, NJ area	x3717	8 a.m.-4:30 p.m. (Rider Wanted)	LOB
Bruce Pierce	800 Trenton Road Langhorne, PA	x3102	8 a.m.-4:30 p.m. (Driver Wanted)	PM&O
Diego DeBonis	119 Frace Street Phillipsburg, NJ	x2349	8 a.m.-4:30 p.m.	Bldg. 1-N
Pat Stephens	846 Riverside Trenton, NJ	x2750	9 a.m.-5 p.m.	Module 2
Leo Lambert	Cliffwood Beach	x2779	8 a.m.-4:30 p.m. (Rider Wanted)	Maintenance
Charles Braswell	10 LaSalle Drive Burlington, NJ	x2893	8 a.m.-4 p.m.	Chem. Science
Roy Jensen	RDI, Rt. 527 Jackson, NJ	x2811	8 a.m.-4:30 p.m.	Aero Lab
John Coulahan	999 Carteret Road Bridgewater, NJ	x2591	8:30 a.m.-5:30 p.m.	D-Site
Doug Bucknum	Solebury, PA	x3263	8 a.m.-4:30 p.m.	C-Site MG
James Simmons	Princeton Junction	x2417	7:50 a.m.-5:10 p.m. (Driver Wanted)	Trailer 1
Michael Mizopalko	71 Harrison Avenue Morrisville, PA	x3223	8 a.m.-4:30 p.m.	LOB

Employees are reminded that carpooling matches can also be made by using the ridesharing map system, located near the C-Site Security booth.

Breakfast Is Important!

What are the criteria for a healthy breakfast? According to the <u>New York Times</u> "Guide to Personal Health," a good breakfast should include fruit or fruit juice, bread or cereal, protein-rich food, and a beverage. If you eat a skimpy breakfast (or none at all), you are likely to experience fatigue from a drop in blood sugar. A healthy breakfast should be low-sugar and high-protein to sustain a steady supply of blood sugar throughout the morning. Beware of eating a doughnut and coffee for breakfast; they give you a quick, sharp boost -- then let you down with a thud!

Plant Maintenance Needs Your Help!

In an effort to reduce wasted energy, the Plant Maintenance and Engineering Department will be monitoring steam leaks and vents throughout the winter. Even small leaks can represent hundreds or thousands of dollars if allowed to continue indefinitely.

Employees aware of a steam or hot water leak, or of steam vapor being vented to the atmosphere, should contact Dick Terhune at ext. 3099, 3416, or 3384. Dick will investigate and initiate appropriate corrective action for each situation.

If you spot other energy-wasting practices or conditions throughout the laboratory, contact Frank Fumia at ext. 2465.

Transitions

The HOTLINE staff offers its congratulations to the following proud new parents:

Rick Galeone and his wife, Patty, whose son, Richard Thomas, was born October 18.

Steve Hendrickson and his wife, Jane, whose son, Steven J. Jr., was born October 12.

PPL Mailrooms No Place For Personal Mail

Rather than simply complaining about the PPL mail system, there's something we can all do to help speed both our personal- and business-related mail service: use the Gun Club mailbox for personal mail.

Mail room personnel pick up and deliver mail to the U.S. Post Office late each afternoon. When personal mail is channeled through the laboratory mailrooms, it is delayed at least one day due to the afternoon dispatch.

However, when mail is deposited in the on-site U.S. mailbox near the Gun Club early in the day, a postal carrier collects it at 10 a.m. The mail is delivered directly to the Roswell Road post office, which dispatches it shortly thereafter.

The Gun Club mailbox was installed specifically to serve laboratory employees. Please use it for your personal mail, rather than the PPL mailrooms.

Safety Training

The following Health and Safety training courses are scheduled for December:

Course	Responsible Instructor	Date Scheduled
General Industrial Hygiene (for Managers and Supervisors)	K. Semel Ext. 2531	December 6 9 a.m.-noon
Back Injury Prevention	M.A. McBride Ext. 3468	December 13 8:30 a.m.-noon
Fire Extinguisher Training	S. Larson Ext. 3166	December 11 2-3:30 p.m.
Cardiopulmonary Resuscitation (CPR)	S. Larson Ext. 3166	December 10, 12, and 14 9 a.m.-noon OR 1-4 p.m.
Self-Contained Breathing Apparatus	S. Larson Ext. 3166	December 19 9:30-11:30 a.m.

Employees must obtain permission from their immediate supervisor to attend these classes. Supervisors must call the responsible instructor to enroll their classes.

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